British Standard

BRITISH STANDARD

BS 3892 :
Part 3 : 1997

Pulverized-fuel ash

Part 3. Specification for pulverized-fuel ash for use in cementitious grouts

ICS 91.100.99

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by Technical Committee B/516, Cement and lime, to Subcommittee B/516/101, Pozzolanas, upon which the following bodies were represented:

British Aggregate Construction Materials Industries
British Cement Association
British Precast Concrete Federation
Cementitious Slag Makers' Association
Department of the Environment (Building Research Establishment)
Electricity Association
Quality Ash Association

This British Standard, having been prepared under the direction of the Sector Board for Building and Civil Engineering, was published under the authority of the Standards Board and comes into effect on 15 October 1997

Amendments issued since publication

Amd. No.	Date	Text affected

The following BSI references relate to the work on this standard:
Committee reference B/516/101
Draft for comment 96/106499 DC

ISBN 0 580 27689 9

Contents

Foreword

This British Standard has been prepared by Subcommittee B/516/101. It takes into account current practice followed in the selection and use of pulverized-fuel ash (pfa) in grout. With BS 3892 : Part 2 : 1996 it supersedes BS 3892 : Part 2 : 1984, which is withdrawn.

Pulverized-fuel ash is extracted from the flue gases of furnaces fired by pulverized bituminous or other hard coal. It is a fine material, predominantly of spherical, glassy particles. Though not reacting directly with water, it can react with the calcium hydroxide in solution produced by the hydration of Portland cements to form additional insoluble hydrates and thus contribute to the strength of grout.

BS 3892 : Part 1 was revised in 1997 and specifies pfa for use in concrete as a cementitious component, defined as a Type II (pozzolanic) addition in DD ENV 206.

BS 3892 : Part 2 : 1996 specifies pfa to be used in concrete as a Type I (essentially inert) addition as it may have both a high sieve residue and a high loss on ignition.

This Part of BS 3892 specifies pfa with higher limits for sieve residue and loss on ignition than specified in Part 1, for use in cementitious grouts.

Where some control over the grout properties is important, such as grouting behind tunnel linings, then performance related tests are required which assess the suitability of the pfa for use in grout. Such tests are included in annexes B and C.

This standard does not apply to grouts for ducts for prestressing tendons, which are specified in BS EN 447[1)].

This Part, in comparison with the 1984 edition of Part 2, introduces the following changes.

a) The methods for sampling and testing are now in accordance with BS EN 196, except for fineness and moisture content, which are in accordance with BS 3892 : Part 1.

b) The requirement has been removed for magnesium oxide content, as research has found no evidence of periclase in pfa from bituminous or other hard coals.

c) Additional tests have been included for fluidity and strength activity to assess the suitability of pfa in grouts for particular uses.

d) Additional guidance on use, safety precautions and storage has been added.

Unlike in Part 1 of this standard, the values given in this Part and in Part 2 are limit values.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 6, an inside back cover and a back cover.

[1)] In preparation.

Specification

1 Scope

This Part of BS 3892 specifies requirements for chemical and physical properties, sampling, testing and marking of pulverized-fuel ash suitable for the production of factory or site blended cementitious grouts. It also includes performance tests for fluidity and strength activity.

It does not apply to grouts for ducts for prestressing tendons.

2 References

2.1 Normative references

This Part of BS 3892 incorporates, by dated or undated reference, provisions from other publications. These normative references are made at the appropriate points in the text and the cited publications are listed on the inside back cover. For dated references, only the edition cited applies; any subsequent amendments to or revisions of the cited publications apply to this Part of BS 3892 only when incorporated in the reference by amendment or revision. For undated references, the latest edition of the cited publication applies, together with any amendments.

2.2 Informative references

This Part of BS 3892 refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on the inside back cover but reference should be made to the latest editions.

3 Definitions

For the purposes of this Part of BS 3892, the definitions given in BS 6100 : Section 6.1 apply, together with the following.

3.1 grout

Fluid suspension containing pfa and cementitious binding agents in water.

3.2 grouting

Placing grout into areas or zones of a structure or ground to improve strength or bearing capacity or to impart stability and resistance against water ingress.

3.3 spot sample

Sample taken from one and the same place relating to the intended tests that can be obtained by combining one or more immediately consecutive increments.

3.4 hard coal

Coal blend giving a gross calorific value of not less than 24 MJ/kg on a dry ash-free basis when tested in accordance with BS 1016 : Part 105.

4 Composition and production

Pfa is a fine powder of mainly spherical, glassy particles having pozzolanic properties which shall consist essentially of reactive silicon dioxide (SiO_2) and aluminium oxide ($A1_2O_3$), the remainder being iron (III) oxide (Fe_2O_3) and other oxides.

Pfa shall be obtained by electrostatic or mechanical precipitation of dust-like particles from the flue gases of power station furnaces fired with pulverized bituminous or other hard coal.

NOTE. Ash from other coals or obtained by other means is not considered in this standard.

5 Moisture content

The moisture content of nominally dry pfa shall not be more than 0.5 % when determined in accordance with the method described in annex C of BS 3892 : Part 1 : 1997.

NOTE. The moisture content of conditioned pfa that has been treated with a quantity of water and conforms to all the requirements of this Part of BS 3892 except clause **5** should be agreed between the supplier and purchaser.

6 Fineness

The fineness of the pfa, expressed as the proportion by mass retained on a 45 μm test sieve conforming to BS 410, shall not be more than 60 % when determined in accordance with annex D of BS 3892 : Part 1 : 1997.

7 Chemical composition

7.1 General

The chemical composition shall be expressed as proportions by mass of dry pfa prepared and dried as described in annex C of BS 3892 : Part 1 : 1997.

7.2 Sulfuric anhydride

The content of sulfuric anhydride (SO_3) shall not be more than 2.5 % (*m/m*) when determined in accordance with clause **8** of BS EN 196-2 : 1995.

7.3 Loss on ignition

The loss on ignition shall not be more than 14 % (*m/m*) when determined in accordance with clause **7** of BS EN 196-2 : 1995 but using an ignition time of 1 h.

8 Sampling and testing

8.1 Sampling

A spot sample of the pfa shall be taken in accordance with **3.6**, clause **5**, **6.2**, **6.3**, **6.4** or **6.5** of BS EN 196-7 : 1992 either before or at the time of delivery.

8.2 Testing

Samples shall be tested at the minimum frequencies given in table 1 for:

a) moisture content (clause **5**);

b) fineness (clause **6**);

c) chemical composition (clause **7**).

Table 1. Testing for each source of pfa

Property	Frequency during production
Fineness Loss on ignition	2 per week
Moisture content Sulfuric anhydride	1 per month

NOTE. The frequency of testing required to ensure conformity to this standard will depend upon various factors such as pfa source and anticipated use.

9 Marking

Pulverized-fuel ash shall be marked on the bag or the delivery note and on any certificate with the following particulars:

a) the name, trademark or other means of identification of the producer and source of the pfa;

b) the name of the material, i.e. pulverized-fuel ash;

c) the number and date of this British Standard, i.e. BS 3892 : Part 3 : 1997[2)].

10 Test certificate

If a test certificate is requested, it shall include results of some or all of the following tests on samples of the pfa relating to the material delivered:

a) moisture content;

b) fineness;

c) sulfuric anhydride content;

d) loss on ignition.

If requested at the time of ordering, the certificate shall also include:

e) fluidity, determined in accordance with annex B;

f) strength activity, determined in accordance with annex C.

11 Sampling and testing for acceptance inspection at delivery

11.1 When required by the purchaser for assessing conformity at delivery, a spot sample of the pfa shall be taken in accordance with **8.1**. A laboratory sample shall be prepared and packed in accordance with clauses **8** and **9** of BS EN 196-7 : 1992. A sampling report shall be completed at the time of sampling and shall be attached to the laboratory sample in accordance with clause **10** of BS 196-7 : 1992.

NOTE. Testing of nominally dry pfa may be delayed for up to 5 weeks from the time of sampling, provided there is confirmation that the sample has been stored continuously as described in **9.2** of BS EN 196-7 : 1992.

11.2 When the pfa is tested for chemical composition as in clause **7**, the sample shall be prepared by the method described in clause **6** of BS EN 196-2 : 1992 except that it is not required to pass a magnet over the pfa to remove metallic iron.

[2)] Marking BS 3892 : Part 3 : 1997 on or in relation to a product represents a producer's declaration of conformity, i.e. a claim by or on behalf of the producer that the product meets the requirements of the standard. The accuracy of the claim is solely the claimant's responsibility. Such declaration is not to be confused with third party certification of conformity, which may be desirable.

Annexes

Annex A (informative)
Product guidance

A.1 Safety warning

Dry pfa in normal use has no harmful effect on dry skin. Precautions should however be taken to avoid such materials entering the eyes, mouth and nose and to prevent skin contact with wet pfa.

When working in places where dry pfa becomes airborne, protection for the eyes, mouth and nose should be worn. If pfa enters the eye it should immediately be washed out thoroughly with clean water and medical treatment should be sought without delay.

This standard applies to pfa to be used in conjunction with Portland cement and other materials in grout. When working with grout, waterproof or other suitable protective clothing should be worn such as long sleeved shirts, full length trousers, waterproof gloves and wellington boots. Clothing contaminated with wet cementitious materials should be removed as soon as possible and washed before further use.

Wet cementitious materials on the skin should be washed off immediately.

Repeated skin contact with wet cement or lime over a period may cause irritant contact dermatitis. Although no connection has been established between pfa and dermatitis, this possibility cannot be ruled out. The abrasiveness of the particles in grout can contribute to this effect. Continued contact during a working day can lead to alkali burns with ulceration, but this is not common.

NOTE. The above guidance is a summary, further information in accordance with the relevant legislation should be sought from the supplier.

A.2 Storage

To protect the pfa after delivery, bulk silos should be waterproof and internal condensation minimized. The provision of aeration is recommended for the storage of pfa in bulk silos.

Pfa conforming to this standard supplied in paper bags should be stored clear of the ground and interlocked for stability, not more than eight high and protected by a waterproof structure. Deliveries should be controlled and used as soon as possible in order of receipt.

Conditioned ash may be stored temporarily in stockpiles. Dust emission can be minimized by either covering the pile or spraying the surface with water.

A.3 Use with Portland cements or other binders

This standard applies to pfa to be used principally with Portland cements conforming to BS 12. Where it is intended to use pfa with cementitious binders other than those conforming to BS 12, specialist advice should be sought from the supplier.

A.4 Use with admixtures and additions

Where admixtures and additions are to be used, their suitability for use with pfa in cementitious combinations should be evaluated.

A.5 Use in grouts

Pfa is blended with cementitious binders either by site mixing or at a factory which supplies the final product as a preblend to meet specific requirements. The blending of the constituents should be performed by a manufacturer with a quality control system equivalent to or better than BS EN ISO 9002.

Where pfa is recovered from stock-piles, hardened lumps in the pfa may cause problems with mixing and pumping the grout. The pfa should be screened to remove such lumps before incorporation into the grout by passing it through a mesh of size appropriate to the aperture of the pump to be used.

In the majority of grout formulations based on pfa and Portland cement, the former will be the main solid constituent. Hence the selection of the correct type of pfa is important from the point of view of both technical performance and cost. All pfa used for grouting purposes should conform to this standard.

A.6 Use in specialist grouts

Where the cementitious grout is required to flow into small spaces or contribute to strength, close control over the properties of the pfa is required to reduce variability of the grout. For these grouts, the pfa should be tested for fluidity in accordance with annex B and/or strength activity in accordance with annex C. The fluidity should not be less than 150 mm when tested in accordance with annex B. The strength activity should not be less than 8 N/mm^2 when tested in accordance with annex C.

The tests for fluidity and strength activity can also be applied to grouts produced by site batching. The limits for fluidity and strength in this instance should be agreed between the parties involved.

A.7 Heat generation

At normal placing temperatures, the cement hydration process generates heat, particularly in the first few days, and large temperature gradients can be produced in large grout sections containing high cement contents. The pozzolanic reaction generates heat at a slower rate than the hydration of Portland cement; consequently an increase in the proportion of pfa to Portland cement can be beneficial in limiting both the rate of heat generation and the peak temperature achieved by the grout mass.

A.8 Sulfate resistance

Research has shown that sulfate resistance of Portland cement grouts can be improved with the use of pfa. However, in particular situations specialist advice should be sought.

Annex B (informative)
Method of determining the fluidity of pfa

B.1 Principle

The fluidity of the pfa is expressed as the flow of a blend of the dried pfa and Portland cement when mixed at a water to binder (pfa plus cement) ratio of 0.4 and tested using a flow channel.

B.2 Apparatus

B.2.1 *Flow channel*[3)], of sheet metal channel, painted or otherwise constructed of a durable material, not subject to corrosion by water and having the shape and dimensions shown in figure B.1. The nominal dimensions of the channel shall be (825 ± 1) mm (length), (76 ± 1) mm (depth) and (102 ± 1) mm (width), as measured from the inside of the walls. The side walls shall be at 90 ° to the base.

B.2.2 *Tundish*[3)], in the form of a conical hopper constructed of a durable material and having the shape and dimensions shown in figure B.1. The nominal dimensions of the tundish shall be (200 ± 1) mm diameter at one end, (36 ± 1) mm at the other, with a length of (116 ± 1) mm.

B.2.3 *Plug*[3)], constructed of rubber and attached to a rigid steel rod, whose shape and dimensions are as shown in figure B.1. The plug shall have nominal dimensions suitable for insertion into the 36 mm diameter hole of the tundish (**B.2.2**) and the length of the rod shall be more than 116 mm.

B.2.4 *Mixer*, as described in **4.4** of BS EN 196-1 : 1995.

B.2.5 *Balance*, of sufficient capacity and capable of weighing to the nearest 1.0 g.

B.2.6 *Flexible scraper*, of rubber or plastics material, suitable for removing grout adhering to the mixer blades and inside surfaces of the mixer bowl.

B.3 Materials

B.3.1 *Reference Portland cement*, conforming to BS 12 standard strength class 42.5 and having an alkali content of between 0.5 % and 0.9 % when tested in accordance with clause **7** of BS EN 196-21 : 1992.

B.3.2 *Distilled water*, to be used for reference testing.

B.4 Mix proportions

The grout composition for each batch shall be as follows:

Portland cement (500 ± 1) g;

pfa (1500 ± 5) g;

water (800 ± 2)g.

B.5 Procedure

Dry the pfa to a constant mass at a temperature of (110 ± 5) °C and allow to cool. Blend the dry cement and pfa mechanically for a minimum of 3 min prior to mixing each batch of grout. With the mixer (**B.2.4**) in the operating position:

a) pour all the water into the bowl and add the binder;

b) start the mixer immediately at the low speed and mix for (60 ± 3) s;

c) stop the mixer and, using the flexible scraper (**B.2.6**), remove all unmixed material adhering to the mixer blades or inside surfaces of the bowl and place it in the middle of the bowl;

d) mix for another (240 ± 10) s at the high speed.

The time interval between the low speed and high speed mixing shall be no more than 30 s.

Immediately after mixing, pour (1.00 ± 0.05) l of the grout into the tundish (**B.2.2**) of the flow channel (**B.2.1**), with the plug inserted in the hole, ensuring that the flow channel is horizontal. Remove the plug and note the travel of the grout along the channel.

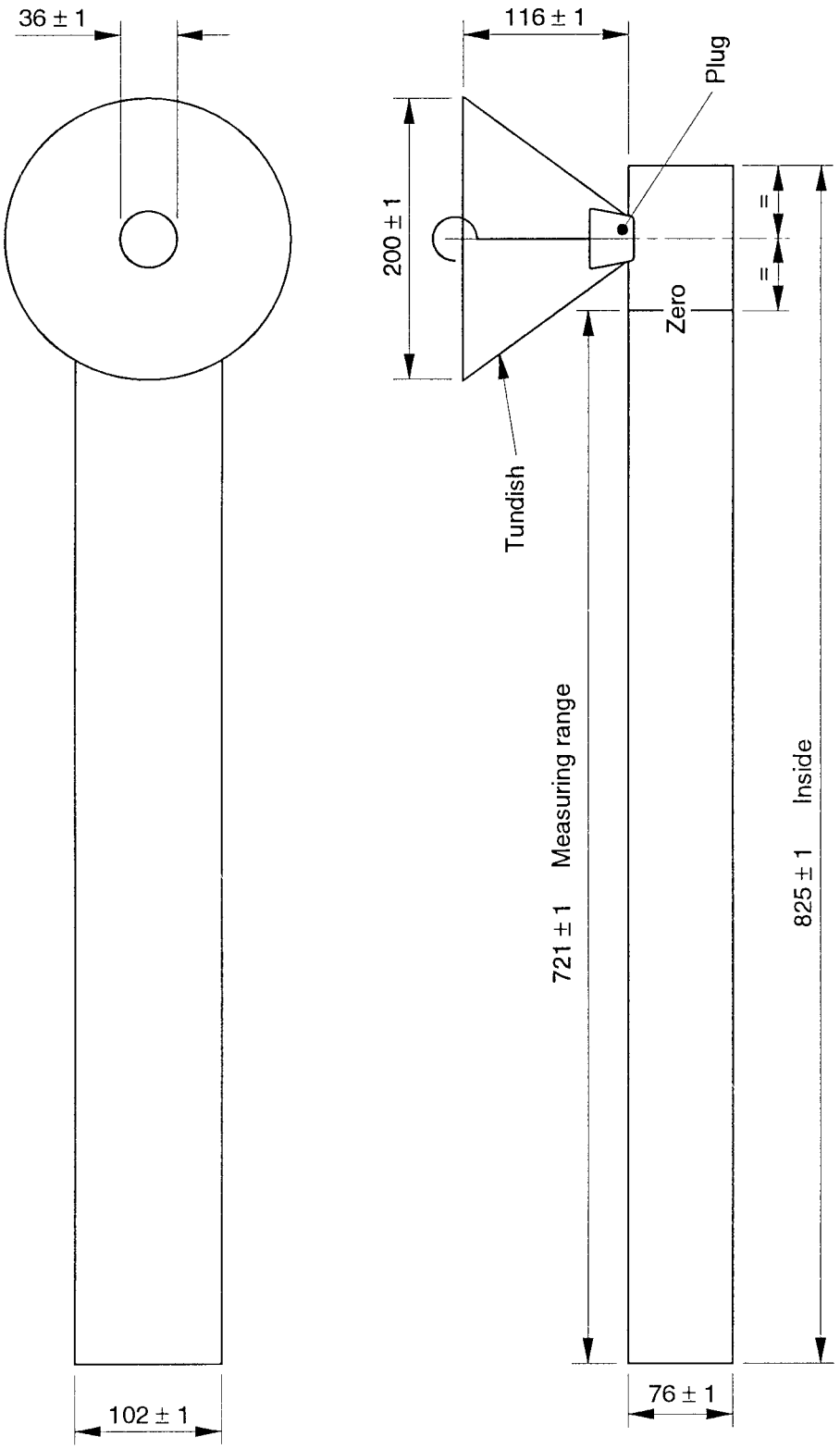
Prior to using the flow channel, wet it thoroughly, stand it on end and allow it to drain for (60 ± 5) s.

Once the grout has ceased to move, measure the flow to the nearest 5 mm, taking the average of the maximum and minimum flow of the front edge of the grout.

B.6 Reporting

Report the fluidity as grout flow to the nearest 5 mm.

[3)] For information on the availability of the flow channel, tundish and plug, write to BSI Information Centre, 389 Chiswick High Road, London W4 4AL.



Dimensions in millimetres

Figure B.1 Typical flow channel

Annex C (informative)
Method of determining the strength activity of pfa

C.1 Principle

The strength activity of the pfa is expressed as the 28 day compressive strength of a blend of the dried pfa and Portland cement when mixed at a water to binder (pfa plus cement) ratio of 0.4.

C.2 Apparatus

C.2.1 *Moulds*, for three 100 mm cubes as described in **3.1** of BS 1881 : Part 108 : 1983.

C.2.2 *Mixer*, as described in **4.4** of BS EN 196-1 : 1995, except that a 10 l bowl and paddle shall be used.

C.2.3 *Curing tank*, constructed from a material which is of adequate strength and will resist corrosion. The internal dimensions of the tank shall be appropriate for the number and size of the specimens to be accommodated, shall permit adequate circulation of water and shall be such that specimens can be easily removed. At any point in the tank where specimens are stored, the temperature shall be (20 ± 2) °C.

NOTE. In order to achieve this temperature control it may be necessary to provide the tank with a lid and/or insulation and/or a water cooling system in addition to the water heating system.

The water used for curing grout specimens shall be pre-conditioned prior to use. This is achieved by adding a blend of the pfa and Portland cement (mix ratio as in **C.4**) to clean tap water to give a solution pH of not less than 12.2. Pre-conditioning shall be carried out for a period of not less than 24 h.

C.2.4 *Thermometer*, suitable for measuring maximum and minimum water curing temperature.

C.2.5 *Compression testing machine*, as described in BS 1881 : Part 115.

C.2.6 *Balance*, of sufficient capacity and capable of weighing to the nearest 1.0 g.

C.2.7 *Flexible scraper*, of rubber or plastics material, suitable for removing grout adhering to the mixer blades and inside surfaces of the mixer bowl.

C.3 Materials

C.3.1 *Reference Portland cement*, conforming to BS 12 standard strength class 42.5 and having an alkali content of between 0.5 % and 0.9 % when tested in accordance with clause **7** of BS EN 196-21 : 1992.

C.3.2 *Distilled water*, to be used for reference testing.

C.4 Mix proportions

The grout composition for each batch shall be as follows:

Portland cement (1500 ± 5) g;

pfa (4500 ± 10) g;

water (2400 ± 5) g.

C.5 Procedure

Dry the pfa to a constant mass at a temperature of (110 ± 5) °C and allow to cool. Blend the dry cement and pfa mechanically for a minimum of 3 min prior to mixing each batch of grout. With the mixer (**C.2.2**) in the operating position:

a) pour all the water into the bowl and add the binder;

b) start the mixer immediately at the low speed and mix for (60 ± 3) s;

c) stop the mixer and using the flexible scraper (**C.2.7**) remove all unmixed material adhering to the mixer blades or inside surfaces of the bowl and place it in the middle of the bowl;

d) mix for another (240 ± 10) s at the high speed.

The time interval between the low speed and high speed mixing shall be no more than 30 s.

Fill the three cube moulds with the grout ensuring that the meniscus is at least 5 mm above the top of the cube. Strike off the excess grout and smooth the surface as described in **7.2** of BS EN 196-1 : 1995. Immediately after making the specimens, follow the procedure given in clause **4** of BS 1881 : Part 111 : 1983.

Cure grout specimens under water separately from other materials such as concrete or mortar until required for testing.

Test a minimum of three cubes for compressive strength at 28 days in accordance with clause **5** of BS 1881 : Part 116 : 1983.

C.6 Calculation

Calculate the compressive strength of the grout cubes in accordance with clause **7** of BS 1881 : Part 116 : 1983.

C.7 Reporting

Report the strength activity as the mean compressive strength for the grout at 28 days to the nearest 0.5 N/mm^2.

List of references (see clause 2)

Normative references

BSI publications

BRITISH STANDARDS INSTITUTION, London

BS 12 : 1996	*Specification for Portland cement*
BS 410 : 1986	*Specification for test sieves*
BS 1016 :	*Methods for analysis and testing of coal and coke*
BS 1016 : Part 105 : 1992	*Determination of gross calorific value*
BS 1881 :	*Testing concrete*
BS 1881 : Part 108 : 1983	*Method for making test cubes from fresh concrete*
BS 1881 : Part 111 : 1983	*Method of normal curing of test specimens (20 °C method)*
BS 1881 : Part 115 : 1986	*Specification for compression testing machines for concrete*
BS 1881 : Part 116 : 1983	*Method for determination of compressive strength of concrete cubes*
BS 3892 :	*Pulverized-fuel ash*
BS 3892 : Part 1 : 1997	*Specification for pulverized-fuel ash for use with Portland cement*
BS 3892 : Part 2 : 1996	*Specification for pulverized-fuel ash to be used as a Type 1 addition*
BS 6100 :	*Glossary of building and civil engineering terms*
BS 6100 : Part 6	*Concrete and plaster*
BS 6100 : Section 6.1 : 1984	*Binders*
BS EN 196:	*Methods of testing cement*
BS EN 196-1 : 1995	*Determination of strength*
BS EN 196-2 : 1995	*Chemical analysis of cement*
BS EN 196-7 : 1992	*Methods of taking and preparing samples of cement*
BS EN 196-21: 1992	*Determination of the chloride, carbon dioxide and alkali content of cement*

Informative references

BSI publications

BRITISH STANDARDS INSTITUTION, London

BS EN 447[4)]	*Grouts for prestressing tendons – Specification for common grout*
BS EN ISO 9002 : 1994	*Quality systems – Model for quality assurance in production, installation and servicing*
DD ENV 206 : 1992	*Concrete – Performance, production, placing and compliance criteria*

[4)] In preparation.

BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: 020 8996 9000. Fax: 020 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: 020 8996 9001. Fax: 020 8996 7001.

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact the Information Centre. Tel: 020 8996 7111. Fax: 020 8996 7048.

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: 020 8996 7002. Fax: 020 8996 7001.

Copyright

BSI
389 Chiswick High Road
London
W4 4AL